as directed spring forces acting in such a way that they feel like detent "slopes" that force the user's finger in a direction, even though they are just pops.

[0133] The overall stiffness of the actuator can affect results. If the user presses too strongly on the moving surface, then the user may move the surface while dragging/pointing the finger and this can run the actuator out of its spring center. A preferred embodiment has a forceful but stiff actuator, one that the user can barely back-drive by pressing strongly.

[0134] Having particular amount of travel or compliance on the moving surface, e.g. about 2 mm, is desirable in some embodiments. There is a strong spring centering from the motor and linkage, and moving the cursor between two objects, such as buttons in a GUI, can be very realistic because the user may perceive true kinesthetic force feedback until finger pressure is decreased and the finger is moved quickly across the screen in a relative mode. The haptic effects which are output are simple tactile pops, and no actual kinesthetic springs are providing force in the X or Y directions. However, the user senses that his or her finger is being pulled into an adjacent object, e.g. the next button.

[0135] It should be noted that kinesthetic force feedback is possible in a different embodiment. For example, if the user keeps his or her finger in one place on the moving surface, and the moving surface has a large enough displacement, forces can be output in the degrees of freedom of motion of the moving surface, providing kinesthetic force feedback. The sensor of the touchpad can be used as the sensor indicating the position of the finger/moving surface for computation of the force, such as a spring force having a magnitude dependent on the distance that is moved from an origin of the spring. Thus, such an embodiment would be a dual mode haptic system, including both tactile and kinesthetic modes.

[0136] Some embodiments of the moving surface may allow sliding by the user, while others may be very stiff with little sliding. In many embodiments, if the maximum permitted movement of the surface is enough to allow traversal between two adjacent graphical targets, then the kinesthetic mode can be effective and user may not notice that he or she is moving the surface—it feels natural. Some embodiments can provide translation and forces in two axes (X and Y), allowing this kinesthetic directed feedback (real springs) in all directions of the touchpad.

[0137] Haptic effects may not feel the same if the user is not moving his or her finger or object on the touchpad. There is often content and value in the correspondence of touchpad motion with the haptic effect (e.g., a detent pop effect). For example, it is effective when the user finger is moving and receiving the pop effect when the finger translates the moving surface to the transition point between the icons or buttons.

[0138] Many of the advantages described above for separate translating surfaces are also applicable to translating the touchpad surface, described in detail below.

[0139] **FIG. 11** is a perspective view of another embodiment **290** of a separate translating surface and moving coil actuator. In this embodiment, a frame **292** is positioned over the touchpad **294** of the device. Frame **292** includes a thin surface portion **296** which is located directly above the touchpad **294** and is thin enough to allow the user's contact on the portion **296** to be detected by the touchpad **294** underneath. Frame **292** also includes an integrated voice coil **298** which is part of a voice coil actuator **300**. The coil **298** can be wire traces that are molded into the frame **292**, which can be a PCB. The other parts of the actuator **300** include a stationary two-pole magnet **302** positioned over the coil **298** and grounded to the laptop housing, and a backing plate **304** made of steel, positioned on the other side of frame **292** and grounded to the housing, and used for a flux return path. The steel subassembly can be attached to the touchpad PCB itself, for example.

[0140] Thus, the magnetic fields of the magnet **302** and the current flowing through coil **298** interact to cause a linear force on the frame **298**, which causes the frame and portion **296** to move as indicated by arrow **306**. This provides haptic sensations to the user similarly to the separate translating surface embodiments described above. The housing can surround the entire frame except for an opening surrounding the portion **296** of the frame **292**. In some embodiments, wires from the coil **298** can be connected to the touchpad PCB using a separate flex circuit finger that branches off of the moving frame **292**.

[0141] **FIG. 12** is a perspective view of another embodiment **310** of a separate translating surface. In this embodiment, a surface surrounding the touchpad is translated in x- and/or y-direction with respect to the touchpad surface. Thumb surface **312** is positioned at the bottom side of the touchpad **314** and is rigidly coupled to a link member **295**. Link member **316** is coupled to a flexible link **318**, which is coupled to the rotatable shaft of an actuator **320** that is grounded to the laptop housing. When the actuator **320** rotates the shaft, the flexible link **318** moves the link member **316** linearly as indicated by arrow **322**, which moves the thumb surface **312** linearly along the x-axis. The thumb surface **312** is shown in sliding contact with a standard button (not shown) which is directly underneath the surface **312**.

[0142] The user can rest his or her thumb, palm, or finger on the thumb surface **312** while operating the touchpad in order to feel the haptic sensations. To press the button located underneath the thumb surface **312**, the user simply presses down on the surface **312**. Overall, the sensations tend to be similar to the sensations for the other translating surfaces described above. In other embodiments, the link member **316** can be much longer to allow desired placement of the actuator **320** in the housing of the laptop or other device.

[0143] One disadvantage is that there is no feedback to the user unless the user has a thumb, finger, or palm on the thumb surface area. The user may have to reach for other buttons to type and then lose the haptic experience. A larger surface **312** or palm pad extension can be used in embodiments in which it may be difficult to keep the user's thumb on the surface **312** while using the same hand to point with the touchpad.

[0144] Touchpad Translation

[0145] These embodiments translate the touchpad surface itself rather than moving a separate surface. The user feels the translating touchpad moving laterally, in shear with his or her skin, creating an immediate sensation. The touchpad can be moved relative to a fixed surround, such as a laptop housing.